Information Visualisation in Battle Management

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Abstract

Visualisation is often thought of as simply the use of computer systems to display processed data graphically, often in a rather colourful and complex manner. More generally, however, visualisation is the human's capacity to utilise effectively and efficiently the output from a computer in order to understand data.

Military operations today depend heavily on the C^4ISR (Command Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance) framework. Unfortunately many military systems make it difficult for users to develop a useful understanding of the information relevant to immediate requirements which is contained within the massive amount of data that flows from the various intelligence sources. The users may not be able to use the systems to extract the information from the data[1], or they may not be able to create displays that allow them to see what they need. Potential information sources may be ignored, or not well used, because techniques for extracting information are deficient. As a consequence, users of many current systems discard much data unassessed. Strategic and tactical actions, simulation and training are all seen to be significantly less efficient than they might be because commanders are not able to access, assimilate and exploit all the available information.

New technologies and data sources now envisaged will require radically improved ways for allowing users to interact with data. Interaction is critical, but at present information is usually presented to commanders, analysts and executives as a passive situation display. Effective visualisation requires the users to interact closely with the visual, auditory and perhaps haptic displays.

This paper describes the UK Master Battle Planner (MBP) [6]. The MBP is an Air Tasking Order planning tool, which aims to provide an adaptive, decision-centred, visualisation environment for UK Joint force commanders. The MBP's developing mission assessment component is also described.

[1] Information and data differ in that information is that which is useful or relevant to the task at hand, wheras data may or may not be relevant to the need.

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Introduction

Military operations today depend heavily on the C^4ISR (Command Control, Communications, Computing, Intelligence, Surveillance and Reconnaissance) framework. This is concerned with the collection, dissemination, processing and interpretation of large volumes of data and information [11]. As battlefield operations become increasingly complex there is an increasing burden on commanders and operations room personnel to act as information assimilators and overseers. Recent conflicts have demonstrated the need for a revolution in the methods for handling the necessary information [10]. This has been found to be especially important for Joint and/or Combined operations where the larger tactical picture is of fundamental importance to the operation planner and controller. Such Joint/Combined operations are, of course, becoming increasingly likely.

An accepted model of conduct is the 'Observe, Orient, Decide, and Act' (OODA) cycle (also known as the Boyd Cycle). The OODA loop is a logical cycle of analysis, planning, implementation and assessment performed by battle commanders, see figure 1:

- ***observe*** the current state of the battlespace (friendly, hostile, neutral forces, weather, terrain etc.);
- ***orient*** own forces to adjust to the changes in the battlespace;
- ***decide*** what to do next (mission planning); and
- ***act*** on these decisions (e.g. fly the missions).

To date, research has tended to concentrate on supporting the *'decide'* and *'act'* stages of this cycle, e.g. the UK Master Battle Planer (MBP). There has, until now, been no research addressing the need for integrated and automated support for the first two stages of the OODA cycle, i.e. *'observe'* and *'orient'*. Developments in these latter two areas will allow the assessment of the actions (e.g. battle damage to targets, mission reports, enemy actions) to be fed back into the early stages of the next cycle in a much shorter time.

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In this paper the UK Master Battle Planer (MBP) and, in particular, its developing mission assessment component are described. The mission assessment component provides the commander and his operations team with real-time feedback for next-step campaign mission planning based on the performance of the accomplished campaign, i.e. the observe/orient/decide component of the OODA cycle.

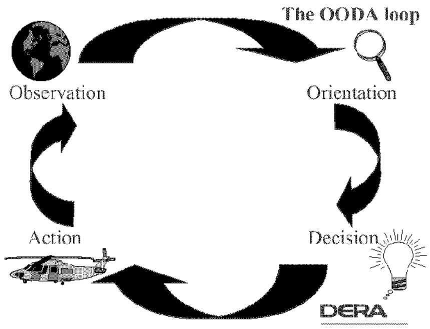

Figure 1: OODA Cycle

Dynamic Visualisation of the battlespace will assist the battle commander and his team in projecting ahead from the orientation stage to decision making, supporting the development of shared mental models and situational awareness. Consequently, it should enable accurate perception of the environment and comprehension of the situation; it should also facilitate projection of future status. For example, if a mission was launched to destroy a bridge the commander will need to know:

- whether the bridge was hit;
- if so, which parts of the bridge were disabled;
- does the mission need to be repeated;
- factors for and against a repeat mission.

In campaigns such as Desert Storm and Kosovo, UK forces currently undergo the OODA loop every 72 hours. In other campaigns, e.g. against guerrilla combatants, or in famine relief, the OODA cycle will need to be much shorter. There is, therefore, an urgent need to be able to assess not only the success or failure of campaign, but also to monitor continuously the detail of campaigns and logistics in a ready and efficient manner, i.e. complete the OODA cycle in a short time (within the enemy's command cycle).

Military Needs

Of paramount importance to the military is the need for flexibility. The prime purpose of military systems is to-deliver military force to achieve an objective, with the most important scenario being war, where failure would be catastrophic. However, there are Operations Other Than War (OOTW) and Low Intensity Conflicts (LICs) where the systems designed for the war scenario lack the required flexibility. For example, an air planning system may enable missions to be planned to drop bombs on a target from 20,000 feet but cannot be adapted to famine relief operations where there are multiple 'targets' and the altitude for the 'package release' is a mere 6 feet.

There are many military Command and Control systems in use today that claim to assist the command team in the performance of their tasks. Unfortunately, the majority of these systems support the process that was prevalent at the time of their design and the systems cannot be changed (easily) to support an alternative process because the process is embedded within the systems. For example, the Improved UK Air Defence Ground Environment (IUKADGE) Command and Control System (ICCS) was designed in the late 1970s and implemented in the 1980s. It was accepted for military use in 1991 and is still in use in today, unchanged. This is despite the changing threat to the UK Air Defence Region, the requirements for more Out Of Area (OOA) operations, and the changing role of the operators it supports.

The above example highlights the problem with old, legacy systems. However, designers are still using the same concepts in new designs. For example, all US forces are mandated to use the Contingency Theater Automated Planning System (CTAPS) for air battle planning. This system is migrating to the Theater Battle Management Core System (TBMCS) which was scheduled to be delivered late 1999. These systems involve a great deal of operator-to-information interaction, but use the traditional method of allowing an operator to access a database, i.e. tables, which allows the operator no flexibility over how the information is presented. This potentially increases operator workload, forcing the user to divert cognitive resources towards operating the system and away from the primary the task, which could result in degraded task performance. Furthermore, the CTAPS and TBMCS systems are designed for US operations and therefore incorporate US doctrine. That is, it forces the operators to follow US rules and offers no flexibility. Furthermore, it is also not very scaleable. It is good for large US-style operations but not very good for smaller UK-led operations, as the overhead in machines and maintenance is tool high. The UK has procured TBMCS for the Pilot Joint Forces Air Component Headquarters (P-JFACHQ) system because in a US-led coalition CTAPS/TBMS will be the mandated system.

It has been accepted that the traditional interface offered to operators does not support them sufficiently, nor is it flexible. It is believed that a layered component-based structure architecture with the user interface as the highest level should be used instead. The user interface must be flexible and configurable (by the operator) to the task being undertaken.

A key element of visualisation is the interface by which the human interacts with the data and includes both the "how" as well as the "what, when, where, and why" of information presentation and control. Visualisation technologies include search engines, algorithmic processes, display and control devices, but the overall visualisation criteria is how these technologies enhance and allow the human to do his job [2,3,5]. A Nato IST-21/TG-007 representation of the overall process [7] is shown figure 2.

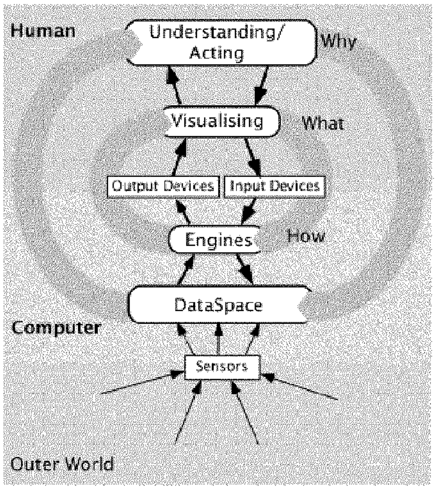

Figure 2: Nato IST-21/TG007 Visualisation Model

Master Battle Planner

The Master Battle Planner (MBP) is a prototype developed by DERA as a result of a study into the operational process of the UK CAOC (Combine Air Operation Centre). A technology gap was identified within the process and the MBP was developed to replace a single, manual procedure in developing the Master Air Attack Plan.
Existing air battle planning systems and CTAPS/TBMS operate on Unix platforms, and make use of large relational databases. At present the displays presented to the operator are still intended to mimic the layout of the database tables, i.e. rows of textual information.

The development of the MBP prototype investigated methods of improving the user interface. It was implemented as a map based system. As far as possible the system was designed to have the look and feel of a standard PC application.

By reducing the fidelity of information, e.g. the characteristics of aircraft and airbases, the need for a large database was removed. This, plus the intuitive design of the user interface, means that the lead-time in populating a scenario for a given operation can be drastically reduced.

A PC implementation also drastically reduces the hardware costs of the system. Whereas CTAPS/TBMCS require a minimum of 9 Unix servers supporting any number of Unix workstations, plus software licences for databases and graphics applications, the MBP can run on a single standard PC, or laptop, with the Windows operating system. This is an important consideration when deploying systems in theatre. A PC can be replaced at significantly less cost and overhead than a Unix platform.

MBP Functionality

The MBP is used to develop an Air Operations Plan. The system also provides the functionality to assist in the development of a defensive plan with the placement of CAPs (Combat Air Patrols) and AEW (Airborne Early Warning) situations.

It provides three stages to the planning:

- Visualise the scenario (figure 3)
- Produce the first cut plan(s) including packages and missions (figure 4) schedules
- Analyse and refine the plans (figure 5, and figure 6)

Visualisation is effective for achieving situation understanding. The scenario can be readily depicted, showing important information such as geographic locations, timing of flight paths, threats, etc. Figure 3 shows an example of this.

Representation of plans is important. Figure 4 shows the first cut plan, it provides key information such as the allocation of available resources and the management of the tasks, etc. It is possible, at a glance, to see if enough resources are available, any overlap or over tasking, etc.

Finally, a preview of the plan is available to analyse the planned mission, figure 7. This is achieved by using a play-mode so that the entire mission or particular package can be rehearsed (visualised) to ensure the success of the planned mission. This preview visualisation shows the mission in motion, it shows the interactions and brings out any mistakes or oversights.

The system can be used in two environments. The first is a large air campaign scenario where a CAOC is in operation for planning operations. In this scenario, the number of aircraft involved requires that high-level planning take place to define COMAO (COMposite Air Operation) packages etc. It is intended that the output from this process will be an ATO (Air Tasking Order) shell. The shell ATO can assist in the generation of the more detailed ATO outputs using available planning tools such as CTAPS or the Nato ICC (Integrated Command and Control).

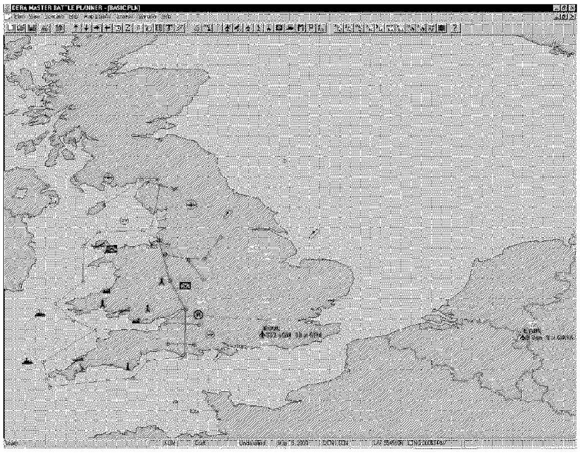

Figure 3: Scenario

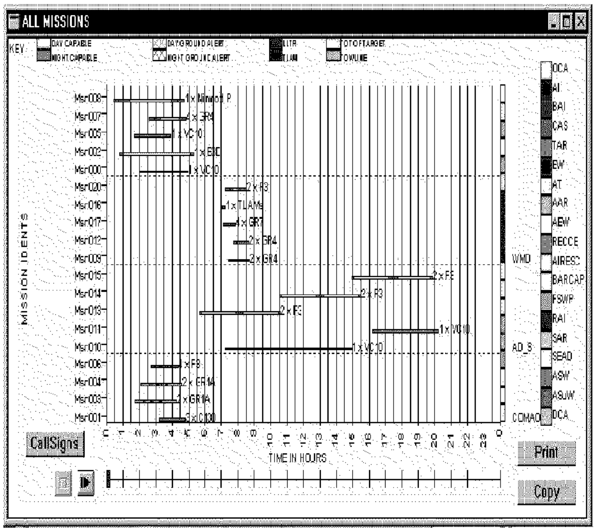

Figure 4: Plan of all missions

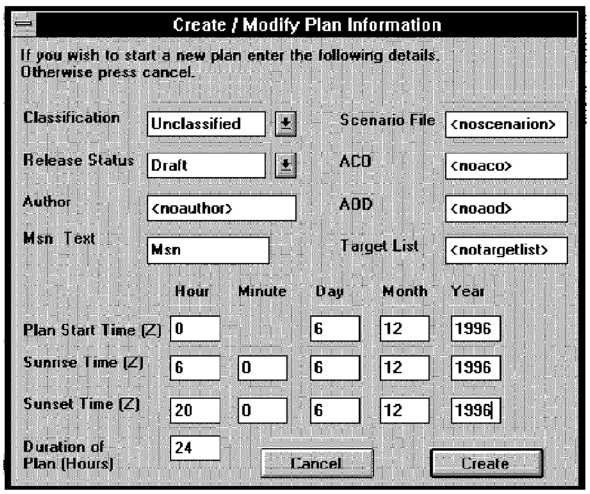

Figure 5: A Mission Plan

In the second operational environment, the system will be used in a small scenario with a small number of Air Units. This negates the need for a complex planning suite such as CTAPS or the ICC and the MBP tool will provide the required functionality to plan Air Operations.

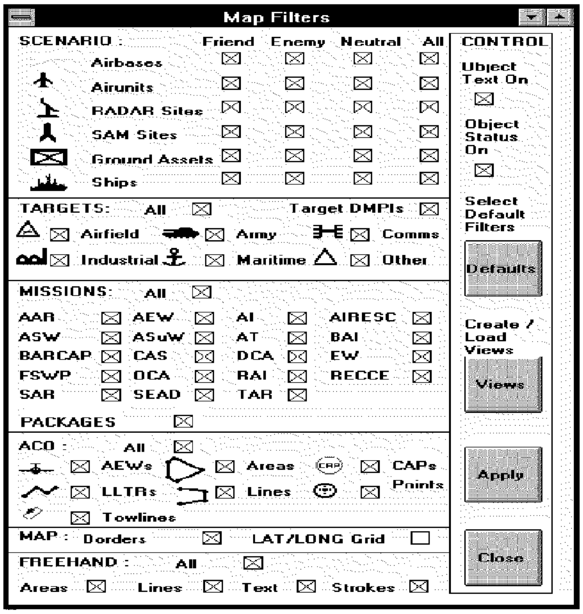

Figure 6: Mission Information

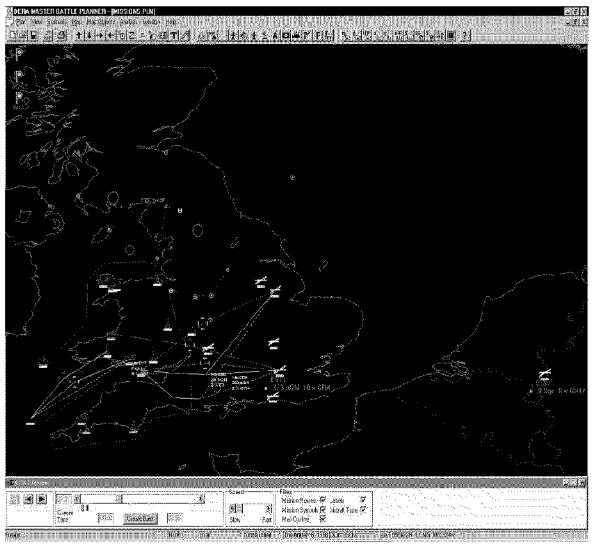

Figure 7: Preview of Mission Plan

Mission Plan

The output from the MBP system will contain sufficient information for it to be disseminated directly to the Wings or lower levels of command. The plans are produced in various formats:

- USMTF
- File importable by MS Office

An example ATO is shown below, it shows the exercise identification (DAIMON) followed by detail of the tasking for each unit. This can be up to 200 pages. During the Kosovo operations, ATOs were several hundred pages long, while ATOs produced during the Gulf campaign were so large that box loads had to be transported to the commanders.

EXER/\\DAIMON\users\hallam\Scenario
Backup\tfm.ATO//
MSGID/ATOCONF/-//
PERID/290000Z/TO:300000Z//
AIRTASK/UNIT TASKING//

TASKUNIT/15SQ/ICAO:LEUC//
MSNDAT/M004/1/OBERON/2GR1/SEAD/-/-/-/32222//
REFUEL/TARTAN67/M001/ESSO/ALT:190/291140Z/0
/<NOFREQ>/<NOFREQ>//
1MSNRTE/NAME/ENTRY TIME/ENTRY PT/EXIT
TIME/EXIT PT/TAS/ALT/INGRESS/291159Z/-
/291209Z/-/ALT:070/-//
ROUTE/291222Z/551400N0015700W//
ROUTE/291224Z/550200N0022000W//
ROUTE/291228Z/550800N0030000W//
ROUTE/291231Z/552000N0032800W//
ROUTE/291235Z/545200N0040300W//
ROUTE/291241Z/551300N0045300W//
ROUTE/291245Z/551300N0054000W//
ROUTE/291247Z/552200N0060000W//
ROUTE/291250Z/554700N0060000W//
ROUTE/291252Z/560700N0063000W//
TGTLOC/291254Z/291254Z/IONA/UNK/561900N0062
200W/-/IONA//
ROUTE/291256Z/563200N0055700W//
ROUTE/291258Z/562800N0053600W//
1MSNRTE/NAME/ENTRY TIME/ENTRY PT/EXIT
TIME/EXIT PT/TAS/ALT/EGRESS/291318Z/-
/291326Z/-/ALT:070/-//

The MBP system enables an operator to build a battle scenario containing airbases, targets, air units, aircraft types, ships, targets, radars, SAM sites, ground units, airspace measures and weapons configuration, using simple dialogs and point and click techniques for object placement on a map background (figure 6). The operator can then plan individual air missions or more complex COMAO packages using a drag-and-drop of objects on maps and data entry in dialog boxes. The system provides the operator with analysis tools to enable the planned operations to be assessed for the best utilisation of resources.

Combat Campaign Assessment

It has been recognised that in order to reduce the OODA cycle time it will be beneficial for the MBP to have direct mission assessment support, so that the planning can be based on up-to-date information on the battlefield in relation to the executed missions.

The aim of the current Combat Campaign Assessment Component research is to investigate and develop technology to create an adaptive, decision-centred, visualisation environment for UK joint force commanders [9]. The commanders will have at their disposal a vast array of sensors, data sources and geographically distributed expertise. They will also be presented with dynamically updated models of the battlefield situation along with a suite of automated planning and decision-making tools. Military success will depend upon the commanders' ability to assimilate this information to understand and control the battlespace.

Vertical visualisation is defined to follow the chain of command. It will allow everyone in the same domain, e.g. in the air domain, to be aware of targets, threats and intentions that will have a direct effect on the deployment of the air forces. This can be achieved by presenting a filtered picture, i.e. a visualisation of the theatre airspace. A similar filtering mechanism can be used to provide a relevant picture to the maritime and land domains [4].

Horizontal visualisation will allow the component commanders to collaborate in Joint strategic planning. Currently there is no tool support to allow the Component Commanders to visualise the progress of a Joint campaign. Provision of accurate, real-time friendly location and combat status information will allow collaborative monitoring and will assist the disparate services to plan and execute a Joint operation towards a common aim.

It is necessary to have secure and responsive information that is available to the right user when needed, i.e. the right information must be delivered at the right time at the right place and in the right format [1,7,8].

Experimental Results

The development stage of the programme has been using an ICCS database. The initial aim has been to visualise the various component of an ATO especially what was planned and what was achieved. This enables the comparison/assessment of the accomplished mission's achievement.

The screenshot of the database, figure 8, shows the task components that were to be visualised and analysed for the next phase of the mission planning. They include:

- ATO_ID
- Mission Number
- Airborne
- Cancelled
- Lost
- Succ

- Unsucc
- Rcancel
- Rlost

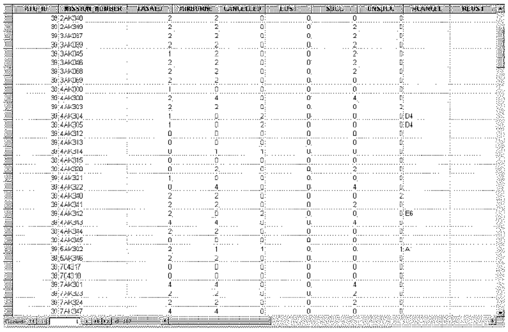

Figure 8: Screen shot of the experimental database

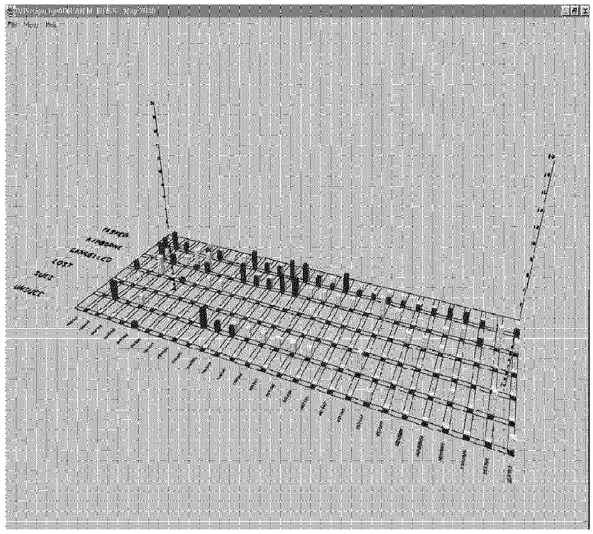

Figure 9: Visualisation of accomplished ATO (view 1)

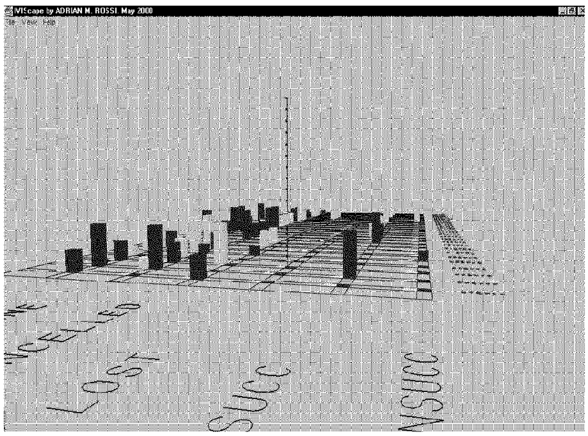

Figure 10: Visualisation of accomplished ATO (view 2)

The visualisation in figure 9 and 10 show the planned mission in blue and what is accomplished in yellow. At a glance one can see that what has been achieved differs from what was planned.

Conclusion

Initial results show that the developing Combat Campaign Assessment visualisation tool has produced encouraging results in providing information on the status of the completed missions within each Air Tasking Order. More work is required to integrate it into the MBP so that a real time mission assessment capability can be made available within the MBP. Thus closing the OODA loop and shorten the command cycle time.

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